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SURVEY METHODOLOGY FOR NORTHERN GOSHAWKS
IN THE PACIFIC SOUTHWEST REGION, U.S.
FOREST SERVICE

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Introduction:

Surveys for Northern Goshawks are conducted by wildlife researchers and land managers to address a number of different objectives. These objectives most commonly include:

- 1) Inventory or census of a study area to estimate density and distribution of goshawks.
- 2) Monitoring previously known goshawk territories to determine occupancy and reproductive success.
- 3) Inventory of specific project or treatment areas to meet NEPA and NFMA mandates for species management.
- 4) Early confirmation of occupancy at nest sites.

The results of surveys conducted to meet objectives 3 and 4 can be used to identify appropriate measures to mitigate disturbance to the species (based on confirmation of nest site or reproductive status) or to determine territory locations for management allocation.

Each of these objectives may require different levels of coverage or confidence to ensure that all territories are detected, and each may be achieved through the use of different survey methods, or through the use of different combinations of survey methods. For example, to investigate the density of goshawk territories within a given landscape, a researcher would need to apply an equal sampling effort over all habitats, using a detection method demonstrated to achieve a specified level of statistical confidence in the density estimate.

In contrast, a manager may not be concerned with detecting or monitoring all territories across a landscape but may instead be interested in having a high probability of determining occupancy in a stand or area scheduled for a potentially disturbing land management activity.

Goshawk characteristics related to survey methodology:

Northern Goshawks (Accipitridae: *Accipiter gentilis*) are uncommon raptors distributed widely throughout nearctic forested habitats. In the Forest Service Pacific Southwest Region, goshawks regularly occupy conifer and mixed conifer-hardwood forest habitats of the Sierra Nevada, Cascade, Inyo-White, Klamath, Siskiyou, and Warner Mountains, and the North Coast Ranges. Occasional sightings and rare reports of nesting occur in the Transverse Ranges and other mountainous localities in southern California. Goshawks have not been reported nesting in the Southern Coast Ranges.

Goshawks inhabit a wide variety of forest habitats, including true fir (red fir, white fir, subalpine fir), mixed conifer, lodgepole pine, ponderosa pine, Jeffrey pine, montane

riparian deciduous forest, and Douglas-fir. They are occasionally found nesting in coast redwood and mixed hardwood forest. Goshawk nest sites tend to be associated with patches of relatively larger, denser forest than the surrounding landscape, however, home ranges often consist of a wide range of forest age classes and conditions. Numerous habitat studies and modeling efforts have found nest sites to be associated with similar factors including proximity to water or meadow habitat, forest openings, level terrain or 'benches' of gentle slope, northerly aspects, and patches of larger, denser trees, but these factors vary widely.

Density and distribution of goshawk territories likely vary with amount and distribution of suitable habitat, however, several studies suggest that territory spacing and density may be quite similar over wide areas. In the Wallowa Mountains (Oregon), Kaibab Plateau (Arizona) and southern Cascades (California) mean nearest neighbor distances were between 2 and 3 miles (Reynolds and Joy 1998, Woodbridge and Detrich 1994, Anderson unpub.). Neighboring nest sites were rarely less than 1 mile apart.

Although notorious for their aggressive defense of nest sites, breeding goshawks are typically secretive and nest sites are often difficult to locate. At specific times, goshawks can be quite vocal in the vicinity of active nests, and it is important for persons involved in survey efforts to be familiar with their various calls (summarized from Squires and Reynolds 1997).

Alarm call: a harsh *kak-kak-kak* repeated many times, typically directed towards intruders near the nest, but occasionally used between pair members.

Wail call: a loud, plaintive, drawn-out call used in communication between pair members. During nesting, female goshawks often wail from the nest, possibly a form of food begging.

Food begging call: a thin, plaintive wail given by nestling and fledgling goshawks to solicit food delivery or express hunger.

Food delivery call: a short, guttural '*kuk*', usually given singly or widely spaced, given by the male goshawk upon entering the nest area with prey. This call typically elicits wailing and frantic begging from the female goshawk and older nestlings, and from fledglings during the post-fledging dependency period.

Factors that affect the effectiveness of survey efforts:

1) Goshawks don't sing.

Because goshawks do not 'sing', surveyors cannot depend on stereotyped behavioral responses to territorial calls – a technique used successfully to census owls. For goshawks, broadcast calling methods are dependent on eliciting defensive responses from adults, or food-begging response from fledglings or the adult female. Compared with territorial song responses, these responses are much more variable and are highly dependent on reproductive chronology and status.

2) Nest site movement: alternate nests.

Goshawk pairs typically use a series of nests separated by a mean distance of 273 meters; a single territory may contain 10 or more alternate nests (Woodbridge and Detrich 1994). Over time, nest sites over ½ mile apart may be used within a single territory (Woodbridge and Detrich 1994, Reynolds and Joy 1998). For these reasons, simple visual checks of previously known nests are not adequate to determine territory occupancy.

3) *Annual variability in territory occupancy, and nest success.*

The ability of any particular survey method to determine occupancy or reproductive status is affected by the probability that a territory is occupied or by the probability of a territory having an active or successful nest. Work conducted to date indicates that northern goshawks exhibit high degrees of annual variation in reproduction (Reynolds and Joy 1998, Keane 1999). Less work has been conducted on determining annual variation in territory occupancy (although we do know that some territories may be unoccupied for one or more years), largely because determining occupancy in territories without successful nests requires intensive and extensive surveys early in the breeding period and adult goshawks on territories without successful nests are difficult to detect. Representative data from the Sierra Nevada indicate the magnitude of annual variation observed (Table 1) (Keane 1999). The proportion of territorial pairs with active nests varied from 22-86% on the Kaibab Plateau of Arizona during the 1990s (Reynolds and Joy 1998). Annual variation in reproduction is associated with variation in prey and weather (Keane 1999).

Table 1. Variation in territory occupancy, nest activity, and nest success for northern goshawks observed in the Lake Tahoe Region, California, during 1992-1995.

Variable	1992	1993	1994	1995	Total
No. Territories	17	17	19	24	77
% Occupied	100	82.4	84.2	87.5	88.3
% Active Nests	100	76.5	47.4	70.8	72.7
% Successful Nests	82.4	47.1	36.8	58.3	55.8

The implications of the results presented in Table 1 for survey efforts are that annual variation in reproduction will likely have large effects on the effectiveness of surveys. For example, only 37% of the monitored territories had successful nests in 1994. If the survey design relied solely on broadcast surveys conducted during the nestling and fledgling periods, such survey efforts could have very low probabilities of locating territories and/or determining occupancy and reproductive status because response rates of non-breeding territorial adult goshawks, or pairs with failed nests, is unknown and probably lower and more variable than at territories with successful nests. Of 13 nest failures recorded during the above referenced study, 11 occurred during the incubation period, 1

during the nestling period, and 1 during the fledgling dependency period. Thus, most territories with active nests that subsequently fail, would have failed before survey efforts were conducted. When considered along with the probability of detection associated with a particular survey technique, and along with the effects of observer variation (see below), annual variation in reproduction can have large effects on the effectiveness of northern goshawk survey efforts.

4) *Nesting chronology and associated behaviors.*

The detectability of goshawks varies during the reproductive cycle. During courtship detectability is high due to courtship vocalizations and over-canopy flights. However, during incubation and the early nestling period adult females are often unresponsive and detectability is very low. Defensive behavior by adult goshawks increases during the nestling and fledgling periods, resulting in increased detectability. As the fledglings reach 2-3 weeks of age, they begin to respond to broadcast of food-begging calls and this accounts for the majority of detections late in the season (July – August).

5) *Observer variability*

No evaluations of the potential bias introduced from observer variation on northern goshawk survey methods and results have been conducted. Observer variation has been demonstrated to affect the effectiveness of wildlife surveys (Verner 1985, Verner and Milne 1989). Experience and motivational levels of observers conducting the fieldwork likely have significant effects on the efficacy of northern goshawks surveys. Often surveys are conducted by seasonal technicians with no or very limited experience with northern goshawk behavior, identification, and survey methodologies. Anecdotal observations on three occasions from the Sierra Nevada indicated that inexperienced crews using broadcast surveys did not locate active nests that were subsequently found by experienced observers using broadcast surveys and stand searches. Research is needed to develop an understanding of the magnitude of observer bias on survey efforts and each of the specific survey methods.

6) *Sensitivity of goshawks to human disturbance.*

During courtship and nestbuilding, goshawks are highly susceptible to human disturbance, and have been recorded to abandon nest areas following human intrusion. Incubating females appear to be unmoved by human intrusion near their nest, but may interrupt incubation for extended periods to defend the nest. Surveys involving physical entry into potential nesting habitat should not be conducted until late May-June. Early confirmation of occupancy should be determined by Dawn Acoustical Surveys or rapid visual checks of known nests from a distance, but no earlier than May 15.

Basic Survey Methods:

There are three primary methods that can be employed to locate goshawks and their nest sites. Each of these methods has it's own strengths and weaknesses, relative to the

objectives and conditions of a given survey effort. In most situations, a combination of methods, depending on timing, amount and distribution of suitable habitat, and available resources, is most effective.

1) Dawn Acoustical Survey:

This method is based on detection of courtship vocalizations and flight displays of goshawks at their nest sites. It consists of establishing "listening stations" in close proximity to known nest stands or patches of suitable habitat, and conducting 1.5-hour listening periods at dawn during the early breeding season (Penteriani 1999).

Primary advantages of this method are that surveys can be conducted early (February-April), about 2-4 months before Broadcast Surveys can be initiated, and that surveys have a *very* high probability of detecting goshawks if present (Penteriani 1999, Dewey and Kennedy *in prep.*). In addition, because surveys are conducted during early courtship, they are less susceptible to nest failure. Only 1-2 listening sessions are required to obtain detections (Dewey and Kennedy *in prep.*).

Penteriani (1999) reported detection rates of 100% at occupied goshawk nests in hardwood forests of southern France. Validation studies by Dewey and Kennedy (*in prep.*) demonstrated a 95% detection rate at listening points <150 meters from 20 occupied goshawk nests during March and April in conifer/conifer-aspen forests in Utah.

Primary disadvantages of this method are: 1) that it may be logistically difficult to apply in areas where access is limited by snow during the period when surveys would be conducted (however, prior success with forest carnivore surveys suggest that use of snowmobiles and skis need not represent an obstacle); and 2) listening points survey a limited area (150 yard radius), therefore many stations may be required to cover large areas such as timber sales. If only 1 year of survey is used, this method may not identify nest stands that are unoccupied during the year of survey.

2) Stand Searches:

This method combines visual searches for signs of goshawk occupancy (nests, whitewash, prey remains, molted feathers) along closely-spaced (50-100 feet) transects (Reynolds 1982), with broadcast acoustical surveys. Goshawk calls are broadcast along within-stand transects simultaneously while visual searches are taking place. This method is best applied to smaller units of area (10-100 acres), following stratification of habitat quality (Reynolds 1982).

Primary advantages: higher probability of identifying nest stand when goshawks are not currently breeding or have failed. Can identify alternate nest stands where goshawks are not currently breeding. Provided that experienced observers are utilized to conduct surveys, this method may be implemented during 1 year. However, 2 years are recommended until validation studies are completed (FY2001).

Primary disadvantages: While we feel that this method is highly effective if carefully conducted, the effectiveness of this method has not been rigorously field-tested, quantitatively evaluated, or compared to other methods. Intensive stand searches are labor-intensive, best suited to assessment of small patches of habitat 10-100 acres in size. Requires a minimum of 3 persons for effective survey. Not likely to detect goshawks nesting over 200m from survey unit. The effectiveness of this method also can vary depending on the time of the breeding period during which it is conducted. In general, the effectiveness of this method increases with time during the breeding season as more sign may be present in occupied nest stands later in the breeding period. However, surveys conducted later in the breeding period may be less effective in territories with early nest failures, particularly in regions where summer, monsoonal precipitation can reduce detection of whitewash.

3) Broadcast Acoustical Survey:

This method is based on broadcast of taped goshawk calls at points along transect routes to elicit responses from defensive territorial adult goshawks. Often termed the "Kennedy-Stahlecker Protocol", it is currently the standard method used by the Forest Service and many others. The efficacy of this method has been evaluated in terms of response rates at *known successful nests* (Kennedy and Stahlecker 1993, Joy et al. 1994, Watson et al. 1999), but currently its ability to detect goshawks at nonbreeding and failed sites is unknown.

Primary advantages; standardized protocol, estimates of effectiveness at successful sites, known rate of effort and cost (Joy et al. 1994, Watson et al. 1999), applicable to large areas of land.

Primary disadvantages; effectiveness unknown at non-breeding or failed sites (Watson et al. 1999, Kimmel and Yahner 1990, Kennedy and Stahlecker 1993). California data on occupancy, breeding and success rates suggest that 20-80% of territories could be missed in a given year due to non-breeding or failed reproductive status if detection rates are low at these sites. A high proportion of responses are from fledglings, which are not present at failed or non-breeding sites. Multiple years of surveys may partially mitigate this factor. Recent work reported by Watson et al. (1999) suggest that increased numbers of surveys/year or closer spacing of sample points (above current protocol) may be needed to increase probabilities of detecting active nest sites.

Watson et al. (1999) reported that the probability of detecting an active nest was affected by the distance from the call point and the number of broadcast samples conducted at a call point. They reported single-visit probability of detections of 0.42 at 100m from active nests, 0.25 at 250m, and 0.20 at 400m. Based on cumulative response curves they estimated that single visits to nests had probability of detections of 60% at 100m and 38% at 250m. Kennedy and Stahlecker (1993) reported detection rates of 73% during the nestling period and 77% during the fledgling-

dependency period at 100m from active nests based on single visits. Little is known about the probability of detecting non-breeding adult goshawks at inactive territories or territories with failed breeding attempts (see Kimmel and Yahner 1990, Kennedy and Stahlecker 1993, Watson et al 1999). Adults at failed territories have been detected during the nestling period, however, few detections have been recorded during the fledgling-dependency period. It is likely that response rates are lower and more highly variable at territories with failed reproductive attempts, and particularly at territories with non-breeding adults, relative to territories with active and successful nests. Several issues require further consideration and research. First, further research is needed to evaluate the relationship between detection rates and distances between sample points. Second, given uncertainty regarding the efficacy of this method in detecting non-breeding goshawks on inactive or failed territories, multi-year surveys are required to have a high confidence in locating active nests (DeStefano et al. 1994). Third, this method is likely very sensitive to observer bias (observer experience and motivation). Finally, the method is labor intensive and can be difficult to fully implement in steep, rugged terrain. Research is especially needed to address possible interactions between observer variability, detection rates (both single distance sample point and overall transect rates) and the distance between sample points.

Developing a Survey Plan to Meet Survey Objectives

Use a step-down approach to 1) reduce the area requiring physical surveys, and 2) maximize efficiency in surveying specific habitats. To create a goshawk survey plan, begin by using habitat data from known goshawk territories in your area (same bioregion, forest type) to create a model of suitable (likely to be occupied) habitat versus low-quality habitat. Model parameters should include forest structure (species composition, size class, density) as well as patch size, topographic features (slope, aspect), and hydrologic features (meadows, riparian habitats).

Overlay map of proposed project area with map of (modeled) suitable habitat, and delineate habitat patches and buffers likely to be affected by project. Overlay map of proposed project area with map of previously known goshawk territories; delete a 1-mile radius surrounding each territory center from survey. This radius is likely to contain the current territory AND unlikely to contain an additional territory.

Based on amount of remaining suitable habitat, patch size and distribution, distribution of known territories, and early-season access, develop survey plan for remaining areas of suitable habitat, using best combination of survey methods 1-3. An example of a step-down survey approach is:

Use Survey Method 1 (Appendix 1) at patches of high-quality habitat, patches with past goshawk sightings and historic nest areas. This allows early deletion of occupied areas from survey area, and allows early inclusion of goshawk management into project planning.

Use Survey Method 2 (Appendix 2) if survey area is small or patches of suitable habitat are small.

Use Survey Method 3 (Appendix 3) if large areas of suitable habitat remain to be inventoried.

Appendix 1: Protocol for Dawn Acoustical Survey Method

1) Timing of Surveys:

Seasonal timing - To coincide with the peak of courtship vocalizations by goshawks at their nest sites, surveys should be conducted during the 1½ months preceding egg-laying. Reproductive chronology likely varies between geographic regions and elevations, and local information should be used to estimate egg-laying dates. Back-dating from estimated ages of nestlings can be used to determine reproductive chronology; use Boal (1994) to estimate ages of nestlings, add 33 days incubation period. For example, if nestlings are typically 15 days old on June 15, surveys should be conducted in your area between March 15 and April 28. Note that during years with particularly cold or wet spring weather, onset of incubation may be delayed for up to 1 month.

Table 2. Estimated dates for the initiation of incubation and hatching for Northern Goshawks in the Pacific Southwest region.

Region	Elevation	Onset of incubation
Sierra Nevada	5500-7500 ft	15 April – 15 May
California Cascades	4900-6800 ft	10 April – 15 May

If there are no detections of goshawks during the first listening session, a repeat session should be conducted prior to May 1. *Two sessions are required to determine unoccupied status.*

Session timing – Observer should arrive and be settled at listening station *at least* 45 minutes before sunrise. Listening session should continue until 1.5 hour after sunrise. Plan carefully so that the entire listening session can be conducted without interruptions for moving position, warming, eating, potty breaks, etc.

2) Establishment of Survey Stations: Listening stations should be positioned within 150 meters of all habitat to be surveyed. Use aerial photographs to determine point location providing optimal coverage of suitable habitat within 150 m radius. To reduce attenuation of sound by surrounding vegetation or landforms, locate stations on slightly elevated position whenever possible, but not on ridges or in large openings. Efficiency may be increased by location of stations on roads; however there may be tradeoffs with position within habitat patches. Stations must be clearly marked to allow their location in darkness.

Whenever possible, establish multiple stations approximately 300m apart to achieve simultaneous coverage of entire survey area by multiple observers.

3) Listening Session Methods: During each listening session, record start and stop time, actual sunrise onset, time and duration of goshawk vocalizations, type of goshawk vocalizations, direction (bring compass) and estimated distance of goshawk vocalizations.

Dewey and Kennedy (*in press*) reported a variety of calls detected during dawn acoustical surveys in Utah. Calls included variations of the alarm call (*kak kak kak*) (Squires and Reynolds 1997) and plaintive wail call (Squires and Reynolds 1997). Length of vocalizations varied from short 1-note call segments to series of alarm calls and wails lasting up to 10 seconds.

4) Locating Nest Sites: Auditory detection of goshawks during courtship indicates occupancy of a particular forest patch; subsequent location of the nest should not be attempted until after the estimated date of hatching. Intensive Stand Searches should be employed to locate nests.

5) Observer Training: The principal requirement of this method is familiarity with vocalizations of goshawks and other species likely to be detected during surveys. Taped examples of goshawk alarm and wail calls, as well as vocalizations of pileated woodpecker, northern flicker, sapsuckers, and Cooper's hawk should be memorized and reviewed prior to conducting surveys.

An important aspect of Dawn Acoustical Surveys is observer transportation during early spring when snow conditions may limit access to many survey areas. Safety and logistical feasibility are important concerns when considering use of snowmobiles and skis before sunrise, often in rugged terrain. However, prior experience with forest carnivore, great gray owl, and goshawk surveys has shown that safe, efficient access is possible under these conditions, particularly if multiple observers are employed to provide assistance. Training in snowmobile use, winter travel safety, and communications are essential for employment of this method.

Appendix 2: Protocol for Stand Search Method

The effectiveness of this method is highly dependent on detection of sign and nest structures, which may be present regardless of current goshawk reproductive status. For this reason, detection of sign or nests triggers an “occupied” status for the stand surveyed and surrounding area. Additional surveys during 1 or more years may be required to locate the nest site and establish appropriate management zones.

1) Establish transect route and coverage: Use aerial photographs and transportation maps to determine placement and direction of transects for optimal coverage of habitat to be surveyed. Determine compass bearing to be used in each survey. Number of observers (and simultaneous transects) is determined by size of habitat patch or unit to be surveyed; typically a minimum of three observers is required. Attempt to ‘anchor’ start and end points of transects on roads, trails, streams or other features.

2) Timing of surveys: Stand searches require presence of multiple observers within nesting habitat and are likely to cause excessive disturbance to breeding goshawks if conducted too early in the nesting period. Do not initiate surveys prior to estimated hatching date (see Appendix 1 table 1).

The effectiveness of stand searches increases as the nesting season progresses, as nestling goshawks become more vocal and whitewash, molted adult feathers and other sign accumulate in the vicinity of the nest. Stand searches are most effective during late June, July and August. Stand searches may be conducted until snowfall; however, detections will be increasingly dependent on sign as adult and young goshawks move out of the nest area in the fall.

3) Number of surveys: If conducted by experienced observers during late June, July or August, a single stand search may be sufficient to determine occupancy status of a habitat patch. However, if *any* sign of presence of goshawks (feathers, old nests) is detected during searches, repeated surveys are necessary to determine nest core location (unless occupied territory status is assumed).

Until studies are conducted to estimate detection probabilities for this method, we recommend that the Stand Search be repeated in the next consecutive year, to increase the likelihood of detecting nest sites unoccupied during the first year of survey.

4) Equipment needed: Broadcast system, ziplock baggies and labels, flagging, compass, reference feather collection

5) Conducting Stand Searches: Following a pre-determined compass bearing, observers should walk parallel transects spaced 20-40 meters apart (40m spacing may be used in open, tall-canopied stands such as red fir or ponderosa pine). Mark the start point of each transect point with individually-marked flagging to allow retracing of survey.

Middle of 3 observers should broadcast recorded goshawk vocalizations at points every 100 meters along the transect (*all observers follow procedure 3 under Appendix 3*).

Searches should be conducted at a leisurely pace, allow ample time for scanning the ground for sign, logs and low limbs for plucking sites, and *all* trees for nest structures. Any sign encountered (feathers, prey remains) should be collected in ziplock bags labeled by transect location. Visual or auditory detections of goshawks should be recorded by transect location and detection type. Careful attention to location of adjacent observers, especially the middle (broadcasting) observer, and compass bearing are important to maintain consistent spacing of individual transects.

At the end of each individual transect, each observer should stop, flag the transect end point, and move to the start point of the next transect. If transects are directed back into the same habitat patch, the 'hinge' or end observer should space the new transect no more than 20 meters from the previous transect; this reduces the potential of unsurveyed strips of habitat between transect groups.

6) Interpretation of survey results: Following completion of a survey, observer notes and collections should be immediately reviewed. Any feathers collected should be identified by comparison with reference samples. Prey remains should be identified and their frequency of occurrence assessed for each transect area. Any reports of whitewash and prey remains should be mapped, based on transect location notes. Entire area actually surveyed should be mapped.

Although whitewash and/or prey remains may indicate occupancy by other predator species, whitewash *and* remains of typical goshawk prey (e.g., snowshoe hare, Douglas squirrel, Stellers jay, northern flicker) are suggestive of goshawk presence, *and trigger "occupied status" and follow-up survey of the suitable habitat surrounding (min. 300 meter radius) the site.* This is particularly true if the initial survey was conducted early in the season, prior to July.

Because female goshawks molt during incubation and nest attendance, their molted flight feathers are typically found in the immediate vicinity of occupied nests. To allow determination of feather source, reference feather collections should contain examples of male and female flight feathers. Male goshawks molt later in the season, and their feathers may be found over a larger area. *Detection of goshawk feathers triggers "occupied status" and follow-up surveys of the suitable habitat surrounding the site (min. 300 meter radius).*

If visual or auditory detection of a goshawk is made during a Stand Search, *and* sign is present in the stand surveyed, the area should be considered occupied. To locate the nest, follow-up surveys of the suitable habitat surrounding the site (300 meter radius) should be conducted 1-2 weeks after the initial survey.

If visual or auditory detection of a goshawk is made during a Stand Search, *but no sign is encountered in the stand*, broadcast acoustical surveys of stand and adjacent stands should be conducted (see Appendix 3).

Appendix 3: Broadcast Acoustical Survey Method

The following survey protocol is based on the methods described by Kennedy and Stahlecker (1993), with modifications from Joy et al. (1994) and Watson et al. (1999). Adjustments to the number of surveys required and spacing of calling stations were made to optimize probability of detection and survey effort and cost. Based on data presented in Kennedy and Stahlecker (1993) and Watson et al. (1999) the survey specifications listed below should have approximately at least an 80% detection rate.

1) Establishment of survey transects and stations: Prior to initiating surveys, use aerial photographs and topographic maps to determine optimal placement of survey transects. Draw detailed maps of survey routes and station location and provide them to field crews conducting surveys. When possible, establish start and end points of transects along existing roads, trails, streams or other landforms. The maximum distance between parallel transects should be 250 meters. Minimize number of stations located on roads, unless roads are entirely within habitat of interest.

Call stations should be located 200 meters apart along each transect. To increase coverage, offset station locations on adjacent transects by 100 meters.

The most important factor in transect and station placement is completeness of coverage; to achieve acceptable confidence in survey results, all suitable habitat should be within 150 meters of a calling station.

2) Extent of surveys: Survey area should include the proposed project area plus an additional buffer beyond the project boundary. For projects involving significant modification of forest structure (ex. commercial thinning), survey $\frac{1}{2}$ mile beyond the project boundary. This distance corresponds to the mean radius of the post-fledging area (about 500 acres) and will allow detection of territories that overlap the project area. For projects that involve minor modification of forest structure (underburning, light underthinning, light salvage) surveys need extend only $\frac{1}{4}$ mile beyond the project boundary.

3) Calling procedure: At each calling station, broadcast at 60 degrees from the transect line for 10 seconds, then listen and watch for 30 seconds. Repeat this sequence 2 more times, rotating 120 degrees from the last broadcast. Repeat 3-call sequence again. After the last sequence, move to the next station. Move (**walk!**) between stations at an easy pace, listening and watching carefully for goshawk calls and sign. The majority of time will be spent walking between stations, so it is important to be alert for goshawks approaching, often silently, to investigate the surveyor. Do not survey from vehicles, or use vehicles to move between stations. Use of two observers probably enhances the probability of visual detections of goshawks, however experienced surveyors may conduct surveys singly. To avoid misidentifying broadcasts of co-workers, simultaneous surveys should be conducted no closer than two transect widths apart.

During the nestling period, broadcast the Adult Alarm call, mixed with the male Food-delivery call. If possible, each calling sequence should begin with the Food-delivery call, followed by 10 seconds of Adult Alarm calls.

During the post-fledging period, broadcast the wail call, mixed with the male Food-delivery call. This call is more likely to elicit responses from juvenile goshawks. Do not survey under conditions such as high winds (>15 mph) or rain that may reduce ability to detect goshawk responses.

Record the type, compass bearing, station number and distance from transect of any responses detected. Attempt to locate goshawk visually and determine the sex and age (adult versus juvenile/fledgling) of responding individual.

4) Number of surveys: This is a 2-year protocol. Surveys should be conducted at least twice during a given year, and repeated twice in the following year.

5) Timing of surveys: Surveys should be conducted during the nestling and fledgling periods, including early post-fledging dependency. Whenever possible, use local information on nestling ages and dates to estimate hatching dates (see Appendix 1). In much of the Sierra and Cascades Ranges, this period corresponds to June 1 to August 15. After August 15, many fledgling goshawks will have moved out of the immediate vicinity of the nest stand, making location of the actual nest more difficult. Surveys may begin ½ hour before sunrise and should cease ½ hour before sunset.

6) Equipment: Effective coverage of a survey area is dependent on the surveyors' ability to broadcast sound that can be detected at least 200 meters from the source. Kennedy and Stahlecker (1993) and Fuller and Mosher (1987) recommend using equipment producing at least 80-110dB output at 1 meter from the source. Regardless of the type of equipment used, broadcast goshawk calls should be audible to at least 200 meters from the calling station.

Until recently, the most commonly used broadcast equipment has been a small personal cassette player connected to a small megaphone. Recent developments include CDs as storage media and improved digital amplifiers that store goshawk calls on internal chips.

Other equipment required for surveys include compass, binoculars, flagging or other station markers, and ziplock baggies and labels for feathers and prey remains.

7) Preparation for Survey: Study the appearance and typical flight patterns of goshawks and similar species prior to conducting surveys. Recent field guides should be consulted to review the field marks of male, female, and juvenile goshawks, as well those of Cooper's hawks, and red-tailed hawks.

Practice recognizing goshawks under field conditions prior to conducting surveys. Forest-wide and Regional training sessions should include visits to a few known nests to allow survey personnel to develop familiarity with goshawk behavior and vocalizations.

Identification of goshawk nests, plucking posts, feathers, whitewash patterns, and typical prey remains are also important aspects of survey preparation.

Learn the typical vocalizations of goshawks and species with similar calls by listening to recorded examples. Field experience is important in learning to distinguish the vocalizations of goshawks from those of mimics such as gray jays and Stellers jays. These species are capable of producing excellent imitations of goshawk calls, particularly the female wail and juvenile begging call, and often respond to broadcast calls. Pileated woodpeckers, northern flickers, sapsuckers and Cooper's hawks also have calls similar to those of goshawks.

8) Interpretation of Goshawk Responses: Surveyors should be aware of different types of responses likely to be encountered during surveys. Joy et al. (1994) classified responses into 3 categories, vocal non-approach, silent approach, and vocal approach. The frequency of each response type varied between sexes, ages, nesting stage, and vocalization broadcasted.

- 1) *Vocal non-approach* – goshawks may respond by perching away from the surveyor, often at the nest, and vocalizing. This response is commonly elicited as begging calls from older nestlings and juveniles, in response to broadcast of either alarm or food-begging calls.
- 2) *Silent approach* – goshawks, particularly adult males, will frequently fly silently in the direction of the surveyor to investigate, and may be visible only briefly. Silent approach by female goshawks during the nestling and early fledgling periods typically indicates an active nest within 200 meters, but male responses may be long distances from the nest. *Failure to detect this common response is a likely cause of poor survey results.*
- 3) *Vocal approach* – commonly in response to broadcast of alarm calls, adult female goshawks (and, less often, males) frequently fly towards the surveyor while vocalizing alarm calls. This response typically indicates the active nest is within 200 meters, particularly if the adult goshawk remains in the vicinity of the surveyor.

9) Interpretation of Survey Results:

Locating active nests – searches for active nests may be conducted immediately following goshawk detections (particularly vocal approaches or attacks), however it is often necessary to review the results from multiple surveys and stations from a larger area to approximate the likely areas to search. Response type, distance and direction from transect, and distribution of habitat should be plotted on aerial photographs, and the Stand Search Method (Appendix 2) should be employed.

Deletion of territories from survey area – following detection of a goshawk, and location (or estimation) of the nest site, an area of 1-mile radius (approximately 2000 acres) surrounding the nest site may be deleted from the survey area.

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